Chemistry 3351: Organic Chemistry
Tuesday: Sept. 25 @ **7:00pm → 9:00** / 1st Exam

Name: Patrick Chaffey (please print, 1 pt)

Page	Possible Points	Score
1	1	
2	9	
3	9	
4	8	
5	10	
6	10	
7	4	
8	9	
9	10	
10	10	
11	10	
12	10	
TOTAL	100	

1. (3 pts each) *Clickers* in action:

a) What is the correct molecular formula for an alkane containing 18 carbon atoms?

A) $C_{18}H_{34}$

B) $C_{18}H_{36}$

C) $C_{18}H_{38}$

b) How many constitutionally isomeric alkenes have the molecular formula C_4H_8?

A) 2

B) 3

C) 4

D) 5

c) Using mechanistic concepts, predict the product(s) in the reaction:

$H_3C\text{-}CH{=}CH\text{-}CH_2\text{-}CH_3 + HI \rightarrow$

A) 2-Iodopentane

B) 3-Iodopentane

C) 2-Iodopentane + 3-Iodopentane

D) 2-Iodo-2-pentene + 3-Iodo-2-pentene

d) Predict the magnitude of K_{eq} for the reaction:

$$CH_3CO_2H + H_2O \rightleftharpoons H_3O^{\oplus} + CH_3CO_2^{\ominus}$$

A) $K_{eq} = 0$ B) $K_{eq} = 1$ C) $K_{eq} >> 1$ D) $K_{eq} << 1$

Acid	pK_a Value
$H_3O^{\oplus}$	–1.7
CH_3COOH	4.7
$NH_4^{\oplus}$	9.3
H_2O	15.7
CH_4	60

e) Select all compounds that contain both ionic and covalent bonds.

I. $CaCl_2$ II. $Ca(NO_3)_2$ III. CH_3CH_3

A) I

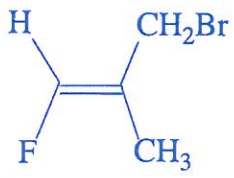
B) II

C) III

D) I and II

E) I, II and III

f) Select the IUPAC name of the compound shown below.



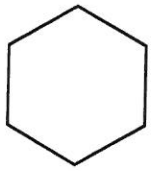
A) (E)-3-bromo-1-fluoro-2-methylpropene

B) (Z)-3-bromo-1-fluoro-2-methylpropene

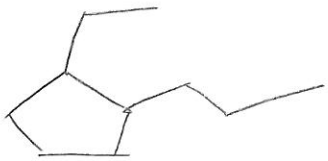
C) (E)-1-bromo-3-fluoro-2-methylpropene

D) (Z)-1-bromo-3-fluoro-2-methylpropene

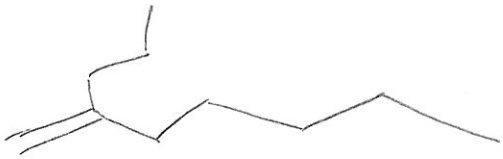
2. (8 pts) Write line structures for each of the following compounds. I have done cyclohexane as an example.



a) 2-ethyl-1-propylcyclopentane

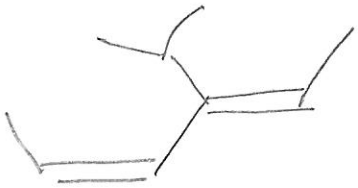


b) 2-propyl-1-heptene



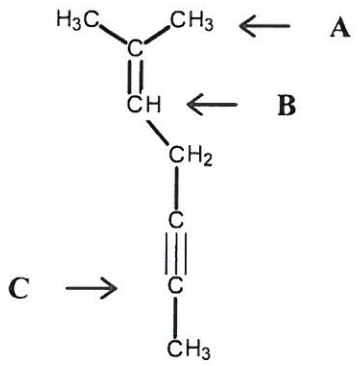
c) 3-vinylcyclohexene

d) (2*E*, 4*Z*)-3-isopropyl-2,4-hexadiene



4. (10 pts)

Determine the hybridization and geometry around the indicated carbon atoms.



Atom A:

- ○ *sp* hybridized
- ○ sp^2 hybridized
- ◉ sp^3 hybridized

- ○ linear
- ◉ tetrahedral
- ○ trigonal planar

Atom B:

- ○ *sp* hybridized
- ◉ sp^2 hybridized
- ○ sp^3 hybridized

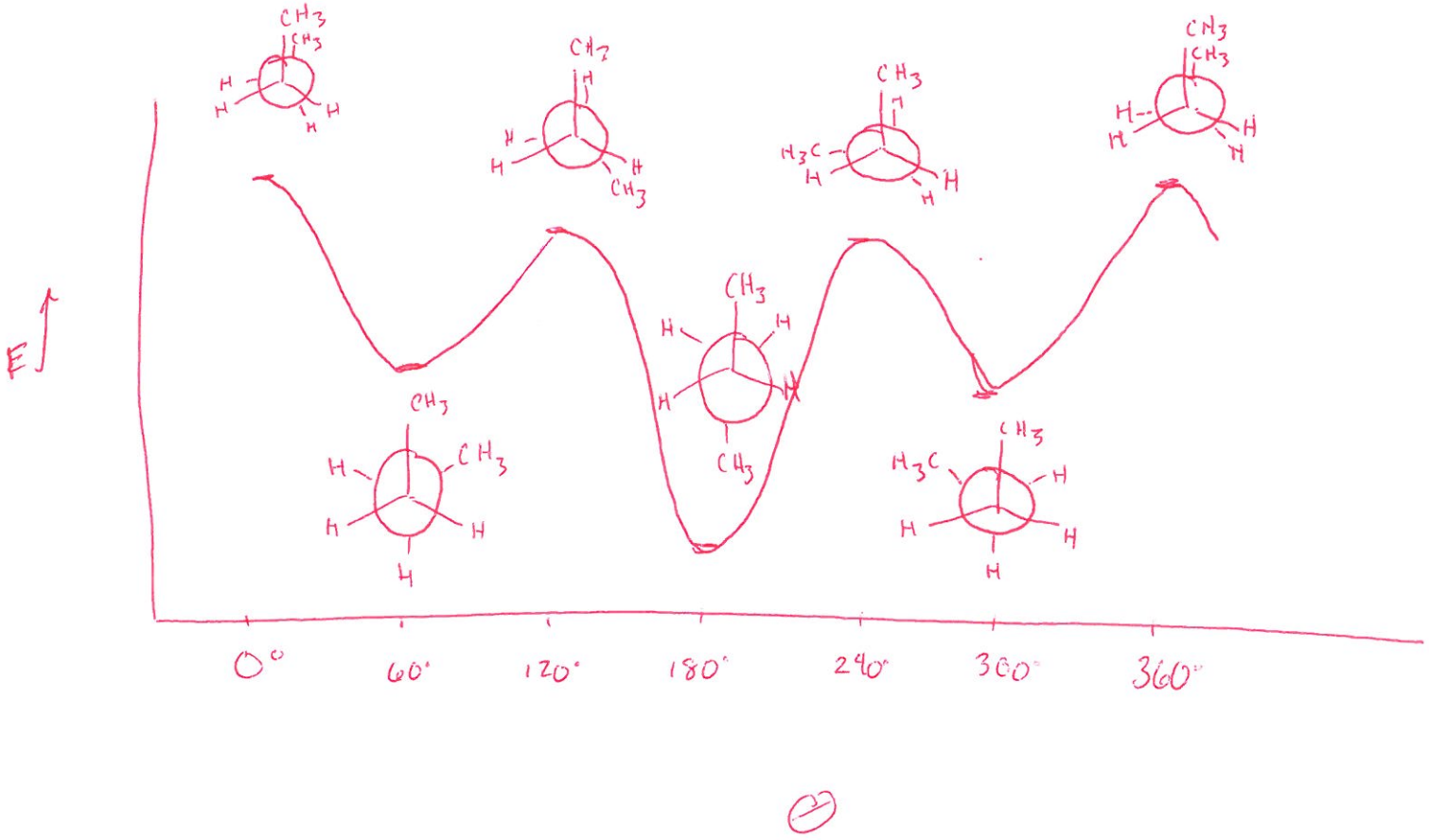
- ○ linear
- ○ tetrahedral
- ◉ trigonal planar

Atom C:

- ◉ *sp* hybridized
- ○ sp^2 hybridized
- ○ sp^3 hybridized

- ◉ linear
- ○ tetrahedral
- ○ trigonal planar

5. (10 pts) Using Newman projections, draw a potential energy diagram for rotation about the C_2—C_3 bond of *n*-butane.



6. (4 pts)

Several alkene compounds are given below. Indicate if each compound can exist as stereoisomers.

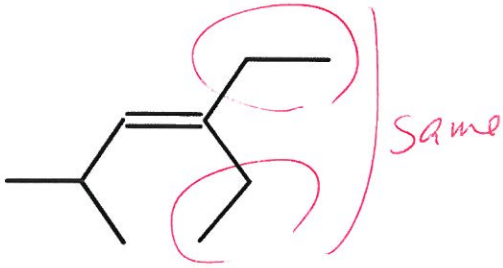
a) $CH_3CH=CHCH_3$

- [x] yes
- [ ] no

b) $CH_3CH=CBrCH_2CH_3$

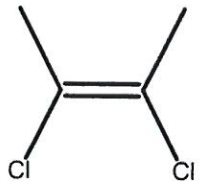
- [x] yes
- [ ] no

c)



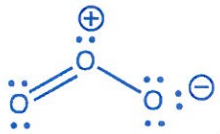
- [ ] yes
- [x] no

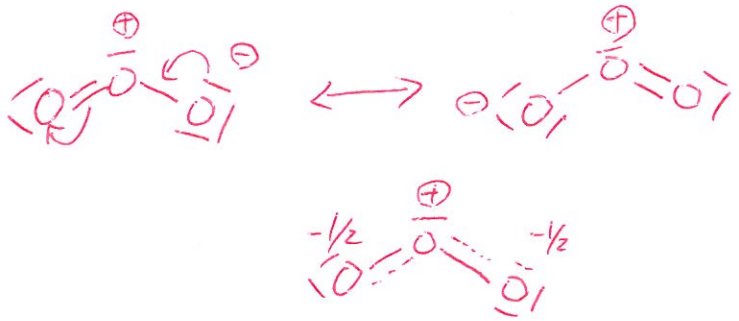
d)



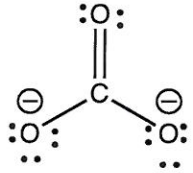
- [x] yes
- [ ] no

7. (9 pts) Use the curved-arrow notation to derive resonance structures that convey the following ideas. In each case, also draw a single hybrid structure using dashed lines and partial charges that conveys the same meaning as the resonance structures.

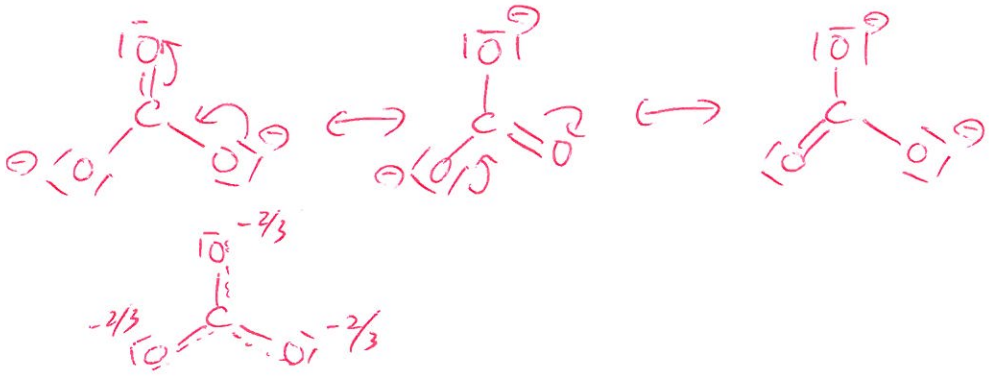
a) The outer oxygens of ozone,  , have an equal amount of negative charge.



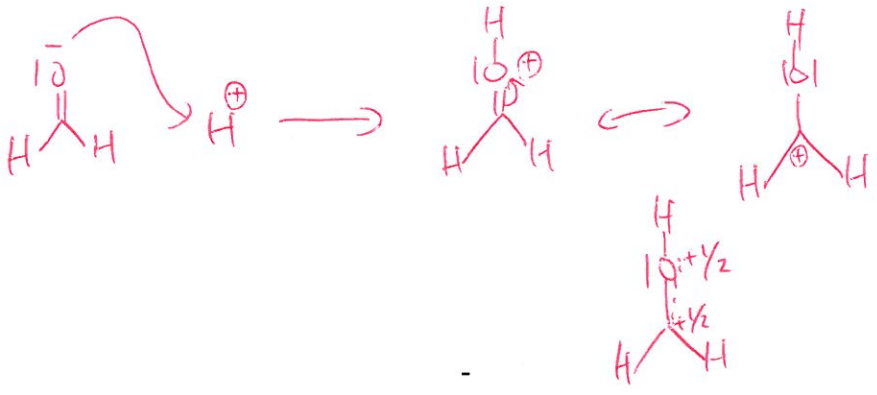
b) All C-O bonds in the carbonate ion are of equal length.



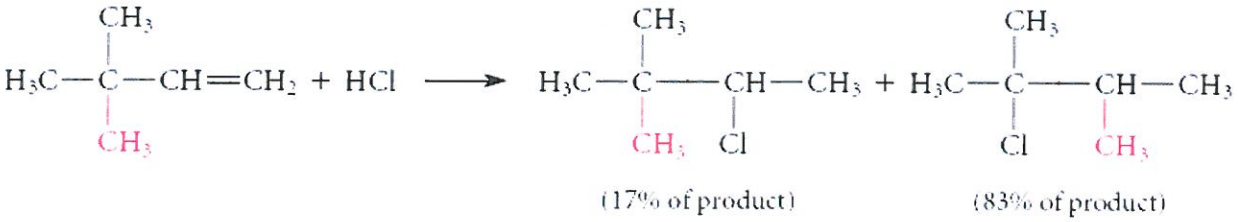
carbonate ion

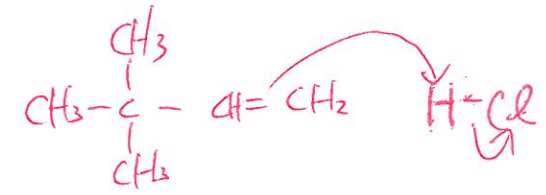


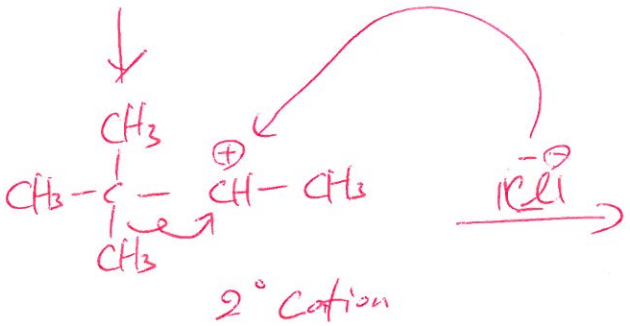
c) The conjugate acid of formaldehyde, $H_2C{=}\overset{\oplus}{O}{-}H$, has substantial positive charge on carbon.

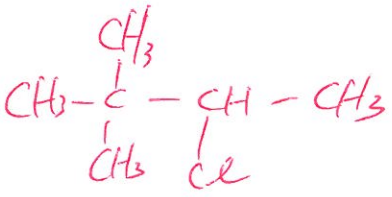


8. (10 pts) Draw the curved-arrow mechanism for the reactions below that accounts for the formation of both products.



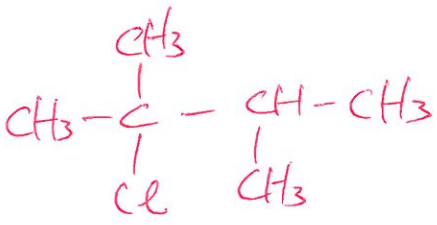






(minor)

(a)



(major)

(b).

3° carbocation intermediate is more stable than 2°.

So, (b) is dominant.

9. (10 pts) Calculate the standard free energy change for the dissociation of acetic acid at 25 °C (pKa = 4.76, molar gas constant R= 8.314×10^{-3} kJ K^{-1} mol^{-1})

$CH_3COOH \rightleftharpoons CH_3COO^{\ominus} + H^{\oplus}$

$\Delta G^{\circ} = -RT \ln K_a$

$= -2.3\ RT \log K_a$

$= 2.3\ RT (-\log K_a)$

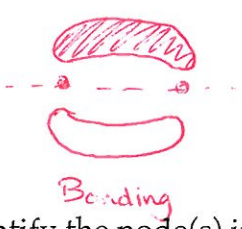
$= 2.3\ RT\ pK_a$

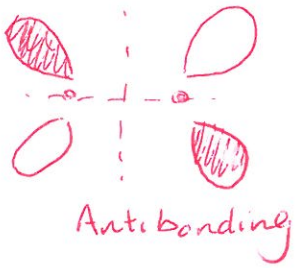
$= 2.3 (8.314\times10^{-3}\ kJ/K\ mol)(298\ K)(4.76)$

$= 27.2\ kJ/mol$

10. (10 pts) Consider two *2p* orbitals, one on each of two different atoms, oriented side to side , as shown below. Imaging bringing these nuclei together so that overlap occurs as shown in the figure. This overlap results in a system of molecular orbitals.

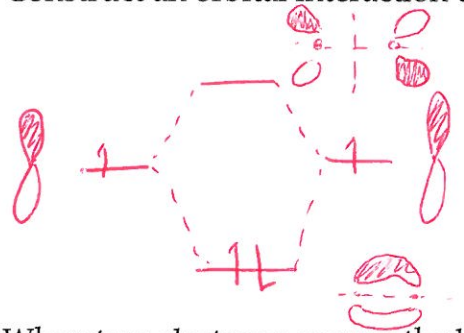
a) Sketch the shape of the resulting bonding and anti-bonding molecular orbitals.





b) Identify the node(s) in each.

c) Construct an orbital interaction diagram for molecular orbital formation.



d) When two electrons occupy the bonding molecular orbitals, is the resulting bond a σ bond? Explain.

No, it is a π bond. No e⁻ density on inter-nuclear axis.

11. (10 pts) Calculate the standard enthalpy difference between the *cis*- and *trans*-isomers of 2-butene. Specify which stereoisomer is more stable. The heats of formation are, for the *cis* isomer, -7.40 kJ mol^{-1} and the *trans* isomer, -11.6 kJ mol^{-1}, respectively.